

National WWTP Effluent Study

James Lazorchak

Acting Chief

U.S. EPA Office of Research and Development (ORD)/National Exposure Research Laboratory (NERL)/Ecological Exposure Research Division (EERD)

(513) 569-7076

lazorchak.jim@epa.gov

Authors: James Lazorchak¹, Marc Mills², Greg Sayles²

¹U.S. EPA NERL

²U.S. EPA National Risk Management Research Laboratory (NRMRL)

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Science Question(s)

Determine how and to what degree human and wildlife populations are exposed to endocrine-disrupting chemicals (EDCs). Determine what effects are occurring in exposed human and wildlife populations. Determine what the major sources and environmental fates of EDCs are. To what extent are estrogenic or androgenic EDCs being discharged into the environment by municipal wastewater treatment plants (WWTPs) as measured by the NERL's fathead minnow vitellogenin (VTG) gene expression assay? Are there any trends in the types of treatment plants or operations of treatment plants that are more or less effective in removing estrogenic or androgenic EDCs? Are there any relationships between the presence of 21 EDC chemicals that the NRMRL has methods for and gene expression activity measured in fathead minnows?

Research

Reports of potential wildlife risk from exposure to environmental estrogens emphasize the need to better understand both estrogenic presence and persistence in treated wastewater effluents. In addition to wildlife exposure, human exposure should also be examined, especially in situations when estrogenic effluents may return to a drinking water supply. This potential has been examined in rivers and reservoirs in the United Kingdom, where they found reduced estrogenicity downstream from wastewater outfalls and no estrogenicity in reservoirs receiving these waters. In 2000, the NERL and the University of North Texas collaborated in a study in which the toxicity and estrogenicity of a final treated municipal effluent was examined.. Male fathead minnows were deployed in the effluent for three weeks. VTG protein, Gonado-Somatic Index (GSI), Hepato-Somatic Index (HSI), and secondary sexual characteristics were biomarkers used in fish models to assess aqueous estrogenicity. VTG gene expression was also measured. There was a very good correspondence in the biomarker and gene expression results. This study provided evidence that the VTG gene expression assay could be used to assess estrogenic EDC exposures in effluents.

In 2002 and 2003, the NERL and NRMRL contacted our ten regional biologists, regional science liaisons, U.S. Environmental Protection Agency (U.S. EPA) inspectors, state U.S. EPA inspectors, and municipal plant operators to voluntarily collect up to 50 effluents and ship them to Cincinnati for male and female fathead minnow exposures. The objective of this study was to

determine whether adult male or female fathead minnows exposed to a municipal WWTP effluent elicited a change in VTG gene expression above or below a lab water control. The goal was to use VTG gene expression results to assess whether certain types of domestic WWTPs or operations are more effective in removing estrogenic EDCs. Of the 50 effluents tested, 13 (26%) effluents upregulated VTG expression in male fathead minnows, two effluents downregulated VTG expression in female fathead minnows, and two effluents that were resampled and tested demonstrated upregulation of VTG in male fathead minnows. This study demonstrated the utility of using the U.S. EPA's male fathead minnow VTG gene expression assay as a tool for screening effluents for estrogenic EDCs. Additional assessment of individual operational information of those wastewater plants demonstrating estrogenicity and similar treatment facilities that did not show estrogenicity need to take place to determine whether certain types of treatment processes and/or operations are more efficient at removing estrogenic EDCs than others. Chemical analyses of effluent samples are currently underway. Results will be used to look for the relationships among the detected estrogens and androgens to gene expression results.

Impacts and Outcomes

This research study initiated the ORD's efforts to monitor EDCs on more than a local scale. Two ORD national laboratories collaborated to expand the scope of a local WWTP study to include samples from several states. The feasibility of sample collection, shipment, and analysis at this scale was shown. Positive findings are setting the research agenda for both future studies and development of additional indicators. Additional studies are currently being planned to look at relationships between the presence of EDCs in effluents and in-stream adverse exposures. An EDC multiyear plan, "Annual Performance Measure," has been generated on the gene expression results and is being distributed to the regions and the Office of Water.

Although this work was reviewed by the U.S. Environmental Protection Agency and approved for publication, it may not necessarily reflect official Agency policy.